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AN OVERVIEW: ANALYSIS OF VARIOUS TECHNIQUE USED IN OFDM FOR REDUCING PEAK TO AVERAGE RATIO

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Abstract

Orthogonal frequency division multiplexing (OFDM) is a multicarrier transmission technique in which single high data rate stream is divided into multiple low data rate stream and is modulated using sub-carrier which are orthogonal to each other . OFDM has several advantages such as high spectral efficiency, flexibility, Easy equalization. Major obstacles that occur in the OFDM is the Peak to average power ratio (PAPR) which causes non –linearity at the receiver end . This Paper will discuss about techniques that helps in reducing the Peak To Average Power Ratio (PAPR) in OFDM.

KEYWORDS

Orthogonal Frequency Division Multiplexing , Peak To Average Power Ratio , Reducing Technique of Peak To Average Power Ratio (PAPR) in OFDM.

1.INTRODUCTION

New technology and thereby new application are introducing not in the wired system but also in the wireless networks. The next generation mobile systems are expected to provide a substantially high data rate to meet the requirements of future high performance multimedia applications. For high data rate and high spectral efficiency new modulation scheme is used that is basically opted by the 4G that scheme is called OFDM. OFDM is the multicarrier transmission technique in which single high data rate is divided into multiple low data rate stream and is modulated using sub carrier which are orthogonal to each other[1].Good solution for the high speed communication is the OFDM through which the data is spread over large number of the orthogonal carrier and each of the carrier is being modulated at a low data rate by appropriate spacing between the carrier they are orthogonal to each other.

OFDM has several advantages such as the high spectral efficiency, flexibility , easy equalization , robustness to channel fading which make more advantageous for the high speed transmission over other transmission technique[2].OFDM has PAPR(Peak to Average Power Ratio) which is the main disadvantage and degrades its performance. The peak to average power ratio (PAPR) is a very important attribute of a communication system as it degrades the performance of High power amplifier (HPA) In OFDM system output is superposition of multiple sub-carriers. With this case the instantaneous power output may increases greatly and become higher than the mean power of system. With high PAPR transmitted signal requires power amplifier with high power scope These amplifiers are expensive and have low efficient cost these amplifiers have high cost low efficiency. If peak power is too high it could be out of the span of the linear power amplifier whoch arises non –linear distortions and changes the superposition of signal spectrum resulting in the performance degradation [11] A low PAPR allows the transmit power amplifier to operate efficiently, where as a high PAPR forces the transmit amplifier to

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have a large back off in order to ensure linear amplification of the signal.[3].

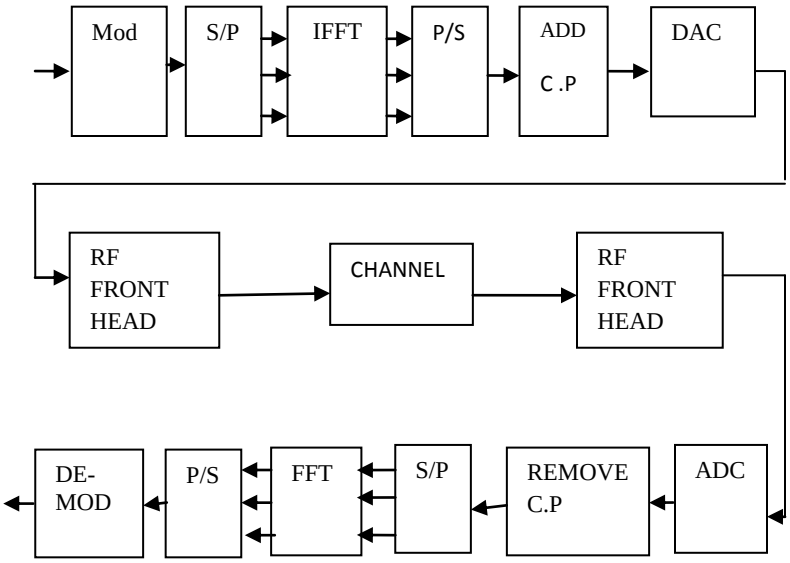

Fig 1:- Basic Block Diagram Of The OFDM

Fig 1 shows the basic block diagram of OFDM in which the input data symbol are supplied to the channel encoder which then mapped onto the BPSK/QPSK/QAM constellation then the symbol is converted from serial data to parallel data by using the serial to parallel convertor then by using the Inverse Fast Fourier transform (IFFT) to achieve the time domain OFDM signal. Time domain symbols can be represented as:

$$X_n = IFFT\{X_k\} \quad (1)$$

$$X_n = 1/N \sum_{k=0}^{n-1} X_k \, e^{\frac{j2\pi kn}{N}} \quad , 0 \leq n \leq N\text{-}1 \quad (2)$$

where,

X_k is the transmitted Symbol on the K^{th} subcarrier

N is the number of subcarrier

In Fig 1 the baseband Digital signal is converted into the analog signal by the help of the Digital –to - analog convertor (DAC) Then, the analog signal . In this block the signal is up converted with the help of the mixer and amplifier and then the signal are transmitted to the antenna In Fig 1 at the receiver side, the received signal is down converted to base band signal by RF frontend. The analog signal is converted into the digital signal with the help of the digital to analog convertor(ADC) Cyclic Prefix is removed from the signal in frequency domain. This step is done by the Fast Fourier Transform (FFT) block. The received symbols in the frequency domain can be represented as

$$y(k) = H(k)x_m(k) + W(k) \quad (3)$$

where, y(k) is the received symbol on the subcarrier, H (k) is the frequency response of the channel on the same subcarrier and W (k) is the additive noise added to , subcarrier which is generally assumed to be Gaussian random variable with zero mean and variance of . Thus, simple one tap frequency domain equalizers can be employed to get the transmitted symbols. After Fast Fourier Transform (FFT) signals are de-interleaved and decoded to recover the original signal.

2. PEAK TO AVERAGE POWER RATIO(PAPR)

OFDM is the multicarrier transmission technique in which single high data rate is divided into multiple low data rate stream and is modulated using sub carrier which are orthogonal to each other[1] .The major drawback in the OFDM signal is the PAPR. The PAPR of the signal s(t) can be defined as the ratio between the instantaneous Power to the Average power can be represented as the [3].

$$\text{PAPR}\{\bar{s}(t)\} = \frac{\max |\bar{s}(t)|^2}{E\{|\bar{s}(t)|^2} \quad (4)$$

PAPR occurs when in a multicarrier system the different sub-carriers are out of phase with each other At each instant they are different with respect to each other at different phase values[2]. In OFDM the PAPR causes the high peak which are larger then the typical values . High PAPR in the transmitted signal will cause the bit error rate degradation inter modulation effects on the sub carriers, energy spilling into adjacent channels and also causes non linear distortion in the power amplifiers[4]. PAPR is a random variable because it is a function of the input data and the input data are random variable. Therefore PAPR can be calculated by using level crossing rate theorem that calculates the average number of times that the envelope of a signal crosses a given level. By

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calculating the complementary cumulative distribution function (CCDF) for different PAPR values can be performed that can be viewed as [5].

$$CCDF = Pr(PAPR > PAPR_0) \quad (5)$$

CCDF computes the power complementary cumulative distribution function from a time domain signal. The CCDF shows the amount of time a signal spends above the average power level of the measured signal or equivalently the probability that the signal power will be above the average power level

3.REDUCTION TECHNIQUES

In OFDM single high data rate symbol is divided into the multiple low data rate streams and modulated using sub-carrier which are orthogonal to each other [1]. The main disadvantage of OFDM is the PAPR which causes high peaks that are larger then the typical values and will causes the BER degradation , non linear distortion in the power amplifiers[5]. There are several techniques which helps in removing the PAPR

1) CLIPPING TECHNIQUE

Due to the High Power Amplifier (HPA) in the OFDM system the signal gets high peak which causes the PAPR in the system. Clipping is the simplest method of reducing the PAPR in the OFDM system. In this the clip or non saturation is employed around the peaks to reduce the PAPR in the OFDM system before the HPA . Due to its simplicity it has disadvantage also such as the Out-of- Band (OOB) radiations ,In-Band (IB) distortions in the OFDM signals and destroy the Orthogonality of the system . There are several types of the clipping techniques such as the simple technique, Peak cancellations technique . .In the simple clipping technique the signal which is above the desired region should be clipped and introduces the OOB radiation, IB radiations in the system. In the Peak cancellation technique improves the spectral efficiency but increases the OOB Radiations , Bit Error Rate [6].

2) SELECTED MAPPING TECHNIQUE

Selected mapping technique is also used for removing the PAPR in OFDM

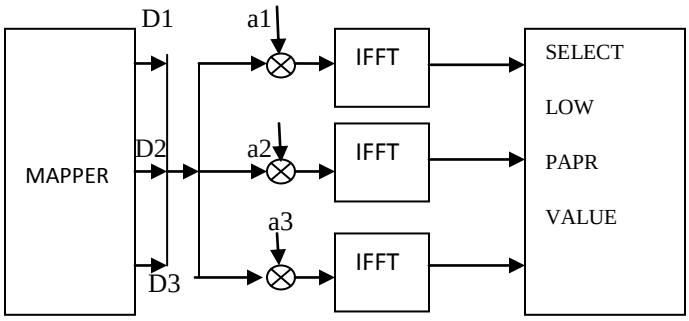

Fig 2 : Selected Mapping

In Fig 2 shows the selected mapping in which single OFDM sequence D having length N by this number of sequence are generated that represent the information using some rotation factor and the sequence with the lowest PAPR is to be selected and transmitted . If the number of generated sequence is U called the SLM length then all the sequence are the result of multiplying the incoming original OFDM D by U different rotation factor. The efficiency of SLM depends upon the amount of scrambling done by these rotation factor on the original sequence of SLM length U. SLM has the moderate computational complexity and complexity depends upon the factor SLM length U. As the U increases the complexity also increases .[7].

3) PARTIAL TRANSMIT TECHNIQUE

Third technique for reducing the PAPR is the PTS (Partial Transmit Technique). PTS is the technique which improves the statistics of the multicarrier signals

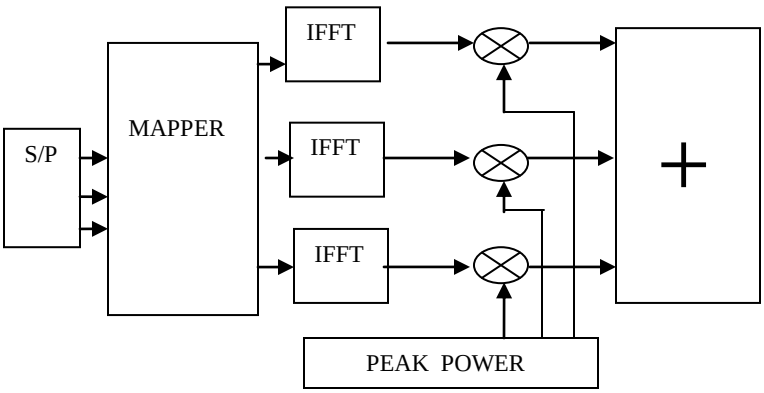

Fig 3 PTS Technique

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Fig 3 the main idea of the PTS is to divide the original OFDM sequence into several sub sequence and each of the sub sequence is multiplied by the different weights until the optimum value is to be chosen. In this the information is divided into several sub sequence by non –overlapping sub-blocks and each sub block is of same length So for each and every sub-block it contains nonzero elements and set the rest part to zero. The sub-block vector is given by

$$X = \sum_{v=1}^{v} b_v X_v \qquad (6)$$

where $b_v = e^{j\varphi_v}((\varphi_v \epsilon [0,2\pi]$

$\{v = 1,2, \ldots \ldots X_v\}$ is a weighting factor been used for phase rotation[8]

4.COMPARISON BETWEEN SLM AND PTS

In SLM complete set of signal represent the same signal but from the desired signal most favorable signal is to selected related to PAPR transmitted SLM is probabilistic based and will not eliminate the peaks but avoid it from frequent generation In PTS the data blocks is divided into non-overlapping sub-blocks with independent rotation factor and generates time domain data with lowest PAPR. this scheme is Probabilistic based.[3]

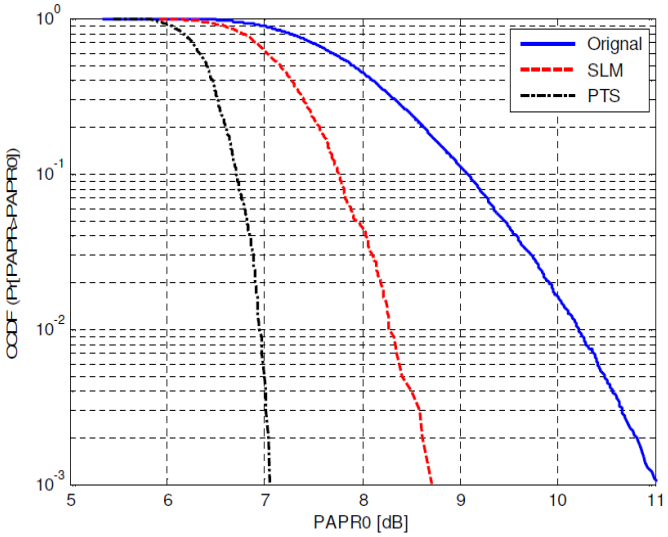

Fig 4 PAPR's CCDF using SLM and PTS method with N=64 [11]

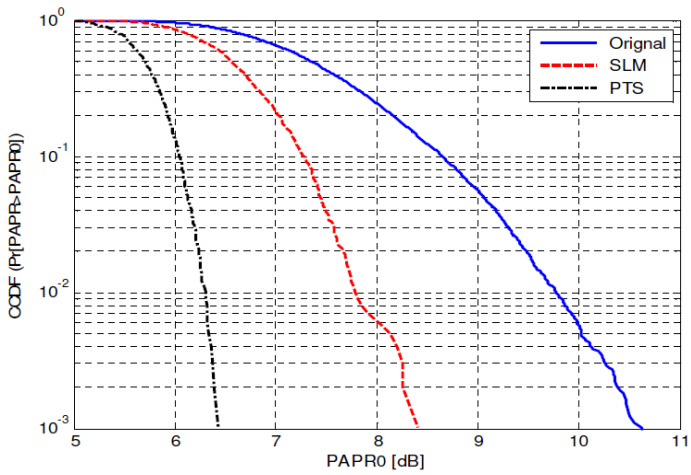

Fig 5 PAPR's CCDF using SLM and PTS method with N=128 [11]

Figure 4,5 shows the CCDF(complementary cumulative distribution function) function of PAPR Distribution of SLM and PTS with 64,128 number of subcarrier respectively. There are several parameters which impact the PAPR performance i.e is the number of Sub–blocks V, which influence the complexity number of possible Phase value W., sub-block partition scheme . As we increase the number of sub-blocks V ,the performance of the PAPR becomes better moreover it is clear from the fig that PTS perform better then the SLM[11] In the above two methods the complexity factor of the algorithm was quite high. This approach provides a trade-off between complexity and performance in SLM and PTS techniques.

5.CONCLUSION

It has been concluded from this paper that there are several advantages of OFDM such as high spectral efficiency, flexibility, easy equalization but Peak to average power ratio arises in it which is the main disadvantage of the it which causes non- linearity at the receiver. High PAPR in the transmitted signal will cause the bit error rate degradation , inter modulation effects on the sub carriers, energy spilling into adjacent channels and also causes non linear distortion in the power amplifiers. There are several technique for removing the PAPR in the such as clipping Technique , Peak windowing ,Selected mapping technique, Partial transmit sequence technique, Tone reservation, Companding .

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Clipping technique can reduce PAPR at different levels but its affects different constraints such as bandwidth expansion, OOB radiations, IB distortion, reduction of spectral efficiency, high peak power. Two typical signal scrambling techniques, SLM and PTS are to reduce PAPR, all of which have the potential to provide substantial reduction in PAPR. PTS method performs better than SLM method in reducing PAPR.

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